1. Formalize the argument below in modal logic and find out whether it is valid.

> If I have hands, there must be an external world. If there is an external world, then I cannot be a brain in a vat. It's possible that I'm a brain in a vat. So, it is possible that I do not have hands.

HW. Formalize the argument below in modal logic and find out whether it is valid.

> Santa's existence is either necessary or impossible. Moreover, Santa's existence is conceivable. If Santa's existence is conceivable, then his existence is possible. So, Santa exists.

2. In Deontic logic (notation: D) the interpretation of $\Box$ is "obligatory", and that of $\Diamond$ is "permissible".

1. What rules shall D obey? What about e.g. $\Box p \to p$?
2. Standard deontic logic: K + $\Box p \to \Diamond p$. What is the frame property that corresponds to this latter formula?
3. (Ross' paradox) Show that in D we have $\Box p \to \Box(p \vee q)$ and $\Diamond p \to \Diamond(p \vee q)$. Argue that:
   - I ought to clean my room. So, I ought to clean my room or burn the house down.
   - I am permitted to write an essay. So, I am permitted to write an essay or plagiarize an essay.
4. The miners puzzle: Kolodny & MacFarlane (2010):

   > Ten miners are trapped either in shaft A or in shaft B, but we do not know which. Flood waters threaten to flood the shafts. We have enough sandbags to block one shaft, but not both. If we block one shaft, all the water will go into the other shaft, killing any miners inside it. If we block neither shaft, both shafts will fill halfway with water, and just one miner, the lowest in the shaft, will be killed.

   From this scenario the following claims seem to be true:

   (a) The miners are in shaft A or shaft B.
   (b) If the miners are in shaft A, we ought to block A.
   (c) If the miners are in shaft B, we ought to block B.
   (d) We ought to block neither shaft.

   Translate each of these sentences into formulas of standard deontic logic and show that they jointly lead to a contradiction.

3. The surprise exam: A teacher announces to her student that she will give him a surprise exam during a term of $n \geq 2$ days. An exam on day i is a surprise if the student does not know on the morning of i that an exam will be given later on. The student, a perfect logician, reasons as follows: "Since the exam will be a surprise, the teacher cannot wait until day n to give the exam, because if she does, then on the morning of day n i will know that the exam takes place, and so it wouldn't be a surprise. [...]"